Global Chemicals Manufacturing
Shifts to the Appalachian Basin

The Shale Revolution 3.0

Tom Gellrich TopLine Analytics
Oct 11, 2017 Utica Summit V – Canton OH
1973 Energy Shock

3.2x Increase
1979 Energy Shock

2.0x Increase
Manufacturing

30%
2008 – 2012 Shale Shock

3.8x Decrease
Manufacturing

30%+
North American Advantage

Source: World bank Pink Sheet Average natural gas prices $/MBtu
Shale Gas Disappointing Global Experience

- Europe – banned or uneconomic
  - France Germany Scotland outright bans
  - Poland uneconomic
- South Africa giant Karoo Basin’s technically recoverable shale gas resource downgraded 30x from 390 tcf to 13 tcf
- Brazil highly anticipated Vale do Juruá field now banned
- Saudi Arabia with all the resources technical, economic and government finally looking to bring on first Shale Gas field
- China’s shale gas deposits dropped by 6% in 2016, as no new shale gas deposits were found
Shale Gas drives the Chemical Industry

Typical Shale Gas

- Methane: 60%
- Ethane: 20%
- Propane: 20%

Fuel

Chemical Feedstock

Source: Typical Shale Gas: Western Marcellus Shale Gas: Chesapeake Investor Presentation 2011
## Ethylene Economics

<table>
<thead>
<tr>
<th>Ethylene Cost</th>
<th>US</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Gas costs</strong></td>
<td>$/MMBTU</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>Crude Oil costs</strong></td>
<td>$/BBL</td>
<td>54</td>
</tr>
<tr>
<td>Equivalent</td>
<td>$/ton</td>
<td>128</td>
</tr>
<tr>
<td>Ratio for one ton ethylene</td>
<td></td>
<td>2.91</td>
</tr>
<tr>
<td>Ethane Feedstock costs</td>
<td>$/ton</td>
<td>165</td>
</tr>
<tr>
<td>Catalyst + Other</td>
<td>$/ton</td>
<td>2</td>
</tr>
<tr>
<td>By Product Credits</td>
<td>$/ton</td>
<td>108</td>
</tr>
<tr>
<td>Utilities</td>
<td>$/ton</td>
<td>94</td>
</tr>
<tr>
<td>Direct Costs</td>
<td>$/ton</td>
<td>167</td>
</tr>
<tr>
<td><strong>Total ethylene Cost</strong></td>
<td>$/ton</td>
<td>321</td>
</tr>
<tr>
<td><strong>Typical ethylene margin</strong></td>
<td></td>
<td>2.50%</td>
</tr>
<tr>
<td><strong>Transfer price for ethylene</strong></td>
<td>$/ton</td>
<td>329</td>
</tr>
</tbody>
</table>

Source: NYMEX Sep 2015
Changes in Global Industry

• M&A: Axiall (Georgia Gulf + PPG Chlor-Alkali)
• JV: PPT Global Chem + Marubeni Corp
• Doubling down on investments: LyondellBasell
  - Relocating existing plants to U.S.: US Methanol
  - “due to U.S. shale gas”
• European + Asian shutdowns: Total Carling
• Increased NA investments: Formosa
• Non – Gulf Coast U.S. investment: Shell
• U.S. Ethane exports: Ineos
• U.S. Backward Integration: BASF
“The feedstock cost for new crackers in [Saudi Arabia] will be around $6/MBtu as there’s not enough ethane availability… this cost will be much higher than the US gas price, which is currently at $3.50-4.00/MBtu.”

— Jamal Malaikah, President and COO, National Petrochemical Industrial Co (NATPET), Apr 2013
Investment Shift

Cancels Al-Karaana Qatar $6.3B Cracker 1/2015

Approves Beaver County $5B+ Cracker 6/2016

Starts up w/Dow Chemical $20B Sadara 8/2016

Announces w/ExxonMobil $10B Gulf Coast 6/2016
50% of all manufacturing investment

Source: ACC analysis of Census Bureau data
Chemical Industry U.S. Investments 2012 to 2022

• $164 billion in capital investment
  – 60% foreign

• Jobs:
  – 738,000 permanent
  – 316,000 temporary

• $301 billion increase in economic output
• $106 billion increase in chemical shipments

Source: American Chemistry Council March 2016
How does translate in global trade and other manufacturing

• Low cost chemicals and plastics go into everything
• US has increasing labor pool, Europe and China have decreasing labor pool
• US has long established manufacturing know how, technical education and acceptance of manufacturing as rise of the middle class
• US has untapped infrastructure of brown field abandoned rust belt sites
• Cost to export finished products is very low – ships go back empty often needing ballast
Appalachian Basin Plastics

Logistics Advantage
- Local Shale Gas
- Local customer demand

Legacy Advantage
- Technical knowledge
- Equipment suppliers

Source: Shell Graphic
Appalachian Basin Logistics

Ethane advantage $12/Bbl
- M. Belvieu price 5/16/17 $26/Bbl
- Cost transport via ATEX $14/Bbl

Polyethylene LLDPE advantage $0.07/lb
- Texas spot 5/12/17 $0.60/lb
- Cost rail transport $0.07/lb

Working capital impact of inventory in pipeline/rail not factored in
Appalachian Basin Ethane

5.5 Conceivable World Scale Crackers
- 1.0 Shell
- 2.5 Rejected by 2020
- 1.3 Rejected future growth
- 0.7 Mariner E

2.3 Unlikely Potential World Scale Crackers
- 0.5 Mariner W
- 1.8 ATEX

World demand is for 4 to 5 new global scale crackers per year
Appalachian Storage Hub

- Key enabling infrastructure
  - Storage plus interconnected pipelines
  - NGLs
  - Chemical building blocks
- Liquidity win/win suppliers/customers
- Déjà vu: key driver behind U.S. Gulf Coast growth
- Minimizes another ‘Katrina’ economic impact
- Reduces risk for new chemical plants
- Numerous bills in Congress and DOE support
- Mountain NGL moving ahead rapidly
Appalachian Basin

Shell broke the ice

- Validation of location
- Demonstrate value to the public
- Local community support
- Build out of ‘eco system’
  - Suppliers and Labor pool
  - Vocational and 2 year degree programs
  - Upgrade of road, rail and barge infrastructure

- Next project will be much easier
- Shell is not done yet...
No large flat sites in the Appalachian Basin

- Requires creative thinking – can be managed
- Acquire and combine multiple sites
- Repurpose and move existing site holders to other locations
- Invest in creating flat land
- Separate elevations, for separate purposes:
  - Office and Labs
  - Raw Material
  - Finished Goods
  - Truck park
  - Cracker
  - Polyethylene unit
No sites in US Gulf Coast >50ft elevation

The risk of hurricanes and flooding is far less manageable. Petrochemical industry is as much driven by risk as it is by ROI.
Katrina, Harvey, Nate

- Once in a thousand years? Twice in a decade?
- Harvey forces shut down of 54% US ethylene
  IHS Markit Sep 5, 2017
- ‘Hurricane Harvey Has Crippled the Foundation of U.S. Plastic Production’
  Fortune Sep 2, 2017
- National impact “U.S. industrial output plunged 0.9 percent in August...Hurricane Harvey's damage to the oil refining, plastics and chemicals industries” Federal Reserve Sept 15, 2017
Katrina, Harvey, Nate

- **Cost of Cracker shut down**
  - Controlled shut down + hurricane over facility + clean up + repair + testing + start up = 18 days
  - 10% of capacity still off line at 24 days
  - 18 days is a loss of 5% of annual production
  - Replaced equipment + overtime + outsourced additional labor + disposal of off spec production = $?
  - Long term loss of customers $?
  - Net bottom line negative easily into 8 figures per facility
- **Same outsourced workforce already stretched with new crackers, maintenance on existing crackers, now on clean-up and repair from Harvey**
- **Additional workforce shortages due to demand for Harvey residential + retail + commercial recovery efforts**
- **Cracker expansions slowed down until ground dries**
<table>
<thead>
<tr>
<th>COMPOUND</th>
<th>AMOUNT (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur dioxide</td>
<td>98,380</td>
</tr>
<tr>
<td>Volatile organic carbon compounds, unspecified</td>
<td>47,975</td>
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<tr>
<td>Carbon monoxide</td>
<td>52,040</td>
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<tr>
<td>Butane</td>
<td>58,647</td>
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<tr>
<td>Nitrogen oxides</td>
<td>64,008</td>
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<tr>
<td>Isobutylene</td>
<td>21,582</td>
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<tr>
<td>Isobutane</td>
<td>36,505</td>
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<tr>
<td>Propene</td>
<td>11,560</td>
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<td>Toluene</td>
<td>21,690</td>
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<td>Ethylene</td>
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<td>1,3-Butadiene</td>
<td>9,540</td>
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<td>Toluene</td>
<td>13,505</td>
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<tr>
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<td>1,840</td>
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<td>1,270</td>
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<td>Ethylene</td>
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<td>1,3-Butadiene</td>
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<td>1,3-Butadiene</td>
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<td>Toluene</td>
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</tr>
<tr>
<td>Ethylene</td>
<td>454</td>
</tr>
</tbody>
</table>

*Source: Texas Commission on Environmental Quality*

August 27-30, 2017
Arkema ‘supply chain effect’

- Arkema Crosby TX produces organic peroxides
- Organic peroxides are polymerization initiators
- Arkema is leading producer, with Crosby TX their flagship facility
- Flooding of the facility caused loss of refrigeration
- Months of inventory decomposed
- Shortage polymerization initiators cause shortages of polymer
- One facility in a highly integrated industry can have a ripple effect to entire supply chain
Harvey... a call to action?

- Implies a shift to Appalachian Basin
- Appalachian Basin is already cost advantaged
- Storage hub provides critical element to reduce risk
- Shell is leading the way, proactively engaging the community, bringing in suppliers, developing a pipeline of trained workers
- Harvey is just another element increasing the attractiveness of the Appalachian Basin
Chemical Industry Drives the Next Wave

>98%

Shale Gas

- Methane
- Methanol
- Ethane
- Ethylene
- Propane
- Propylene
- N-Butylene
- Butane
- Isobutylene

Product Categories:
- Fertilizers
- Adhesives / Sealants
- Alkyd Resins
- Solvents
- Corrosion Inhibitors
- Textiles
- Inks, Adhesives
- Shampoos, Detergents, Soaps
- Paints
- Coatings
- Pipes, Hoses, Wire Coating
- Coolant, Antifreeze
- Films, Packaging, Bottles
- Paint Remover
- Plastics
- Tires and Rubber
- Lubricant Additives
- Solvent, Industrial Cleaners

Market Sectors:
- Apparel and Accessories
- Beverages and Tobacco Products
- Chemicals
- Computer and Electronics
- Fabricated Metal Products
- Food and Kindred Products
- Leather and Allied Products
- Machinery, Except Electrical
- Nonmetallic Mineral Products
- Paper
- Petroleum and Coal Products
- Pharmaceuticals
- Plastics and Rubber Products
- Primary Metal Manufacturing
- Printed Matter and Related Products
- Textile and Fabrics
- Textile Mill Products
- Transportation Equipment
- Wood Products

Source: PwC and TopLine Analytics
Next Wave

Shale Gas

- Methane
  - Ammonia
  - Methanol
- Ethane
  - Ethylene
  - N-Butylene
- Propane
  - Propylene
- Butane
  - Isobutylene

Polyethylene
- EDC
- EPDM
- Ethanol
- Alpha Olefins
- Vinyl Acetate
- Ethylene Glycol
- Ethanolamine
- Ethyl Oxylates
- Glycol Ether
- Chloro Ethanes
- Polyvinyl Chloride

Source: PwC and TopLine Analytics
Shale Gas Conclusions

• The U.S. Shale Gas revolution has caused a **Global Chemical Industry revolution**

• Chemicals and manufactured products can be produced far cheaper in NA

• Implications are disruptive and offer opportunity

• Appalachian Basin is the new frontier

• Leaders lead, is your organization mobilized?
We assist companies in addressing the challenges and opportunities to compete in the changing landscape brought on by the shale gas revolution.